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Cover: The very large and strong-flying robberfly *Blepharotes coriarius* Wiedemann is widespread across eastern Australia. *Blepharotes* contains six described and a similar number of undescribed species, restricted to Australia and New Guinea. They are easily recognised by their flat, usually yellow or orange abdomens, that bear dense, lateral tufts of hairs. From an original drawing by Geoff Thompson.

THE SPREAD AND IMPACT OF THE INTRODUCED VESPINE WASPS *VESPULA GERMANICA* (F.) AND *VESPULA VULGARIS* (L.) (HYMENOPTERA: VESPIDAE: VESPINAE) IN TASMANIA

RICHARD BASHFORD

Forestry Tasmania, GPO Box 207, Hobart, Tas 7001

Abstract

The dispersal since introduction and current distribution of the two vespine wasps present in Tasmania, *Vespula germanica* (F.) and *Vespula vulgaris* (L.), is documented. The economic effects on agriculture, forestry and tourism are outlined and an appraisal of possible environmental impacts made.

Introduction

The European wasp, *Vespula germanica* (F.), was first found to be established in Australia in the Hobart suburb of Battery Point in 1959 (Anon 1960). Since then this species has expanded its range throughout the settled regions of the island and in recent years become firmly established in National Parks, uninhabited areas of the south-west and rainforest areas in north-western Tasmania.

Originating in Europe and the Mediterranean region, *V. germanica* is now widespread throughout the world including North America, Chile, South Africa, New Zealand and Australia. Its presence in New Zealand dates from sightings in the 1920s but it was not confirmed as established until 1944 (Thompson 1982). The species spread throughout New Zealand in about six years, its rapid dispersal accelerated by its survival through the relatively mild winters of the region. A similar event occurred in Tasmania following confirmed establishment in 1959 in Hobart. Within ten years the wasp had become widely established in the north of the state and within a further five years penetrated the rainforests of the west coast and now occupies most of the state. The number of nests established in high rainfall areas fluctuated annually but in recent years *V. germanica* seems to have gained a permanent foothold in many areas thought to be marginal for its establishment.

The English wasp, *Vespula vulgaris* (L.), a species similar in appearance to the European wasp, has recently been found established in southern Tasmania (Matthews *et al.* 2000). Examination of museum specimens shows that the species has been present in the Hobart area since 1995 and is currently restricted to the south east of the state. *V. vulgaris* was first found in Australia in the Melbourne area in 1958 and has not greatly expanded its range. In New Zealand this species is widespread throughout most of the country and in some areas, such as the South Island beech forests, has usurped *V. germanica* (Clapperton *et al.* 1994).

General life history

The adult workers of both *Vespula* species are primarily protein feeders and are swift, voracious hunters of many insects, especially larger Diptera and honeybees. The wasps also gorge on ripe fruits such as apples, plums, grapes and berry fruits as well as meat from carrion and barbecue areas.

Overwintering queens emerge from hibernation in spring and establish new nests. The nests are never exposed, usually being found in hollow trees, under rock slabs, in cavity brick walls or under big logs. They are constructed from wood fibres collected by the workers and mixed with saliva to form a papier-mache nest filled with breeding cells. Eggs are laid in the golf ball-sized nest and the first adult workers emerge several weeks later. Workers live for several weeks, continually increasing the size of the nest. Increasing numbers of adult workers are produced during the summer months with populations peaking at up to 20,000-30,000 workers per nest in March/April. Workers tend to forage within 200 metres of the nest but individuals may travel up to a kilometre. In autumn the nests begin to decline and several hundred queens and male wasps are produced in larger cells. Mating occurs outside the nest, the drones die and the queens migrate to find overwintering sites. The remaining workers usually die, leaving the nest deserted. However in well-sheltered nests resident queens and workers may survive and remain active during the winter, resulting in increased nest size and large wasp populations the following year. These nests may survive and enlarge for up to three seasons. The largest recorded *V. germanica* nest in Tasmania occupied 2.268 cubic metres in volume (Lewis 1975).

Most wasp colonies in Europe die out over the winter months, with overwintering queens re-establishing nests each spring. There is only one generation a year. The survival of the nest, which can house up to 100,000 insects, is temperature dependent, with mortality occurring at 0°C after 12 hours (Madden 1981). High rainfall and prolonged periods of frost and snow may limit the permanent distribution of the wasps in some areas of Tasmania although *V. vulgaris* is able to survive in colder and wetter sites than *V. germanica* (Beggs 1991).

Pest status

Vespid wasps cause crop losses to many agricultural industries especially soft fruit orchards, horticultural ventures, apiaries and the wine and grape industries. Their presence and aggressive nature pose health threats to outdoor workers in agriculture, forestry and tourism. Both species are aggressive if individuals or the nest are disturbed and pose a hazard to people using machinery during forestry and agricultural operations or in recreational areas such as picnic grounds.

European wasps are economic pests of beehives, robbing them of honey and killing worker bees when foraging. No estimates of losses are available from

Tasmania but in New Zealand destruction of 1.9% of all hives and damage to another 4.9% of hives in 1974/75 resulted in serious losses to the industry (Walton and Reid 1976). By 1986/87 the annual total of destroyed and damaged hives had risen to 9.35% (Clapperton *et al.* 1989). Movement of wasps into native forest areas also deprived beekeepers of considerable potential honey production as a result of competition with bees for honeydew in beech forests (Crosland 1989). However, a Tasmanian study did not demonstrate any significant competition between wasps and bees for the leatherwood flower resource used for honey produced in wet forest areas (Ettershank and Ettershank 1993).

The increased area of grapes grown for wine production in Tasmania provides an attractive food source for wasps in autumn when foraging activity is at its peak. Although losses in Tasmania have not been documented, in the 1999/2000 season several southern vineyards reported a loss of grape production of up to 25%. This was due to fruit damage to grapes being hollowed out by wasps; consequently picking was brought forward by several weeks to minimise crop losses. Trapping in some vineyards in the south of the state has shown the presence of both *Vespula* species. In Victoria losses of 10-15% of the total crop due to damage by *V. germanica* has been recorded (Thomas 1993). Wasp damage in some vineyards in Victoria was responsible for bringing the harvest date forward and in recent years there has been an increased incidence of pickers and processors being stung (Darby *et al.* 1998). Wasp feeding reduces the content of the grape and also introduces foreign yeast types that can interfere with the fermentation process (M. Williams, pers. com.).

One Tasmanian commercial grower of strawberries reported a 20% loss in fruit production in 2000 due to wasp damage. The wasps are attracted to sugary substances and aggregations can occur at fruit processing plants and fruit and confectionery shops.

Although not reported in Tasmania, in Israel there has been an increasing incidence of European wasps feeding on milk from lactating dairy cattle, causing bacterial ulcers affecting up to 65% of cows in some herds. There was also a higher incidence of nests on dairy farms (Braverman 1998).

Spread of *Vespula germanica* in Tasmania

Records of wasp sightings and nests were compiled from newspaper reports, observations of forestry workers and public inquires as well as personal observations. Figure 1 shows the distribution throughout the state for each decade since establishment based on confirmed sightings. Spradbery and Maywald (1992) stated that by 1974 the wasp was widespread throughout Tasmania. Since then there have been periods of several years in western coastal areas where wasp populations have been very low due to high rainfall flooding nests. However, since the early 1990s populations have been high.

This suggests that the occupancy of good nesting sites had enabled the population to recolonise flooded sites or marginal habitats quickly. Several very large nests have been found, especially among the roots of large dead eucalypts, in very high rainfall areas (<2000 mm per annum), suggesting occupancy for several years. This trend of permanent occupancy of good nest sites has occurred throughout the state over the period of establishment, ensuring that there will always be high wasp populations in Tasmania. The experience in New Zealand suggests that this 'permanency' phase may take up to 20 years to be achieved before a plateau of population numbers will occur. The other moderating factor to permanent establishment is the food resource.

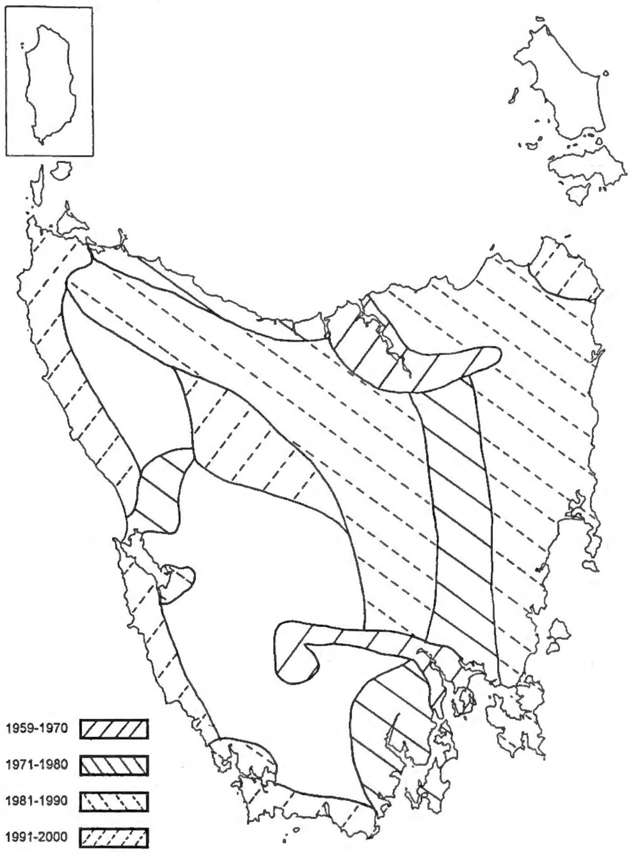

Fig. 1. Distribution of the European wasp, *Vespula germanica*, in Tasmania for each decade since introduction.

Spradbery and Maywald (1992) noted that the initial establishment and spread of *V. germanica* is largely dependent on man and the urban environment. Colonisation of sub-optimal habitats is dependent on suitable nest sites, over-wintering sites for queens and a food resource that can sustain high wasp populations. Nest density is dependent on site availability. In New Zealand at a disturbed land site the density reached 75 nests per hectare (Szabo 1993).

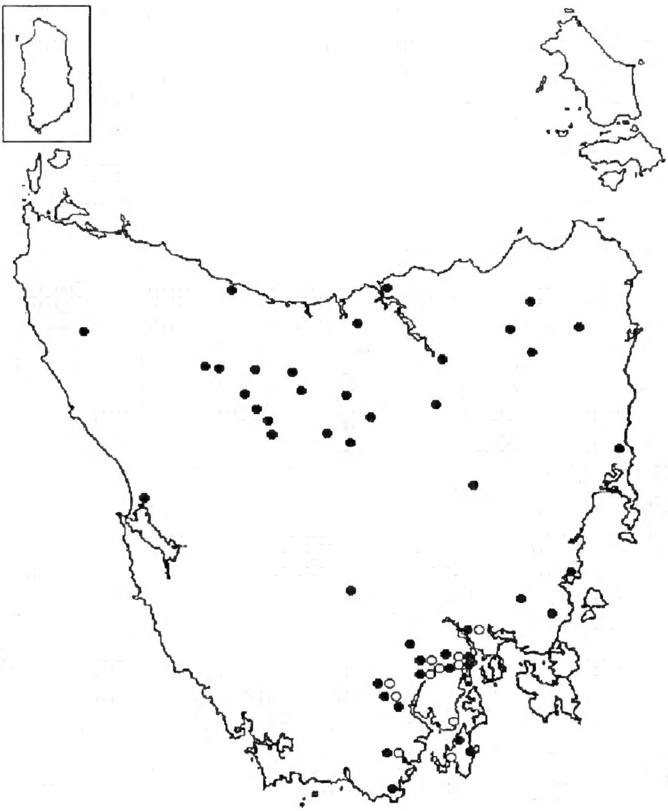

Fig. 2. Distribution of *Vespula germanica* (●) and *V. vulgaris* (○) in Tasmania from a survey conducted in April 2000.

Spread of *Vespula vulgaris* in Tasmania

Following the discovery of *V. vulgaris* at Warra in the south of the state (Matthews *et al.* 2000), an examination of museum specimens determined presence in the Hobart area dating from 1995. A small survey was conducted

during April 2000, during which Forestry Tasmania staff, Australian Entomological Society members and university students collected vespid wasps either by live capture or utilising commercial wasp traps. Totals of 745 *V. germanica* and 51 *V. vulgaris* wasps were collected from 47 sites (Fig. 2). *V. germanica* was collected at all but one site while *V. vulgaris* was present at most sites south of and including Hobart suburbs. *V. vulgaris* was not found at midland or northern sites. At most sites small numbers of wasps were collected. At sites where both species coexisted, *V. vulgaris* was in low numbers compared with *V. germanica.* At one Hobart suburban site however, *V. vulgaris* dominated (ratio of 4:1, n = 65). At Warra, where large numbers of wasps were collected at nine sites, the ratio of the two species in 1999-2000 was almost 1:1 (n = 316). Clearly trap position will influence the numbers of each species captured if a trap is inadvertently placed near a nest. The distribution of *V. vulgaris* may have been underestimated and its presence at some sites overlooked, given the low catches at many sites. However, out of 111 specimens collected in the state north of Hobart, none was *V. vulgaris.*

Movement of wasps into high rainfall areas of western Tasmania

Vespula germanica was first recorded in the west of Tasmania at Queenstown in 1971 and in the coastal Strahan area in 1974. There seems to have been little movement from these population areas until 1988, when wasp nests were found at the top end of Macquarie Harbour and then at Port Davey in 1991. By 1997 all coastal areas of the South-West National Park were inhabited. In some areas along the southern coastal track many walkers complained of large numbers of wasps attending campsites. The north and central-west coastal areas, including the Arthur River rainforest, were all occupied in 1987 by well-established populations. The coastal strip between the Arthur and Pieman Rivers was one of the last regions of Tasmania to be regularly occupied but by 1993 the wasps were a common sight to forestry and survey workers (Mesibov 1993). Since 1993 there have been yearly reports of nests throughout the south-west regions of Tasmania by bushwalkers, forestry and national park workers, indicating that the wasp has become established in western regions of Tasmania. Initial colonisation in favourable seasons enables nests to be built in marginal sites, which subsequently are effected by flooding or low temperatures. However, initial colonisation also enables good sites to be occupied and support later movement into marginal areas.

Vespula vulgaris is reported as being more tolerant of colder and wetter conditions and higher altitude than *V. germanica.* With the establishment of this species in Tasmania it may be able to colonise areas which are marginal for *V. germanica* (Fordham *et al.* 1991, Beggs 1991). Of concern are the potential occupation of the interior of the South-West National Park and the alpine regions of central Tasmania.

Impact on native fauna

The establishment, in the southern forests of Tasmania, of a long-term ecological research site (Warra LTER site) where research into sustainable logging systems is being conducted, provided the opportunity to examine the impact of the *Vespula* species on the native invertebrate fauna. As part of baseline invertebrate studies, using Malaise traps, *Vespula* species have been captured at nine routinely monitored sites in sufficient numbers to enable some initial impact comments to be made.

During the initial set up of the Warra site, involving cutting tracks and marking boundaries during the summer months of 1996/97, workers did not observe the presence of *Vespula* species. This suggests that, if present, populations and nest numbers were very low. Since mated queens and foraging workers rarely fly more than one kilometre (Rogers 1972), nest establishment at the Warra site appears to have commenced in the summer of 1996/97 with migration from Tahune Park, adjacent to Huon River, where *V. germanica* has been present for at least 15 years. The wasps appear to have followed the new road and colonised disturbed roadside ground, then moved mainly into logged coupes containing very disturbed ground and then into nearby native forest. Native forest, on the edge of logged coupes, is used by foraging workers of both *Vespula* spp., with *V. germanica* preferring open areas and avoiding areas of closed canopy.

At Warra, between November and June in 1997-1998, wasps were collected at nine Malaise trap sites distributed throughout a two square kilometre area. Low trap catches of between 1-9 wasps per trap [mean 1.29 (64 trap times)] were recorded. In 1998/99 during the same months, all sites recorded captures of between 1-50 wasps per trap [mean 8.9 (61 trap times)]. In 1999/2000 traps captured 1-42 wasps per trap [mean 8.6 (35 trap times)]. Table 1 presents the capture over time of the two wasp species at Warra. Two Malaise traps situated in an open logged area accounted for 20% of the total wasps caught. In the three seasons of sampling a total of 854 wasps was captured in the Malaise traps.

In 1998/99 seven wasp nests were found at newly disturbed roadside sites along the length of the study area and two nests were found in an undisturbed coupe. No nests were found in 1997/98. High populations of wasps were present during March to June in both 1999 and 2000 in a coupe logged the previous winter, where there were many nests in disturbed ground. Many of these nest sites may not be suitable for winter survival in adverse conditions. In New Zealand, Donovan (1997) recorded high nest density during the establishment phase in disturbed ploughed land at 137 nests/hectare for *V. vulgaris*. This density reflects the utilisation of potential nesting sites, many of which would not survive adverse weather conditions.

Table 1. Seasonal capture of *Vespula germanica* and *V. vulgaris* in Malaise traps at Warra (data pooled from 9 traps for each month).

Year	Month	*Vespula germanica*		*Vespula vulgaris*	
		Queens	Workers	Queens	Workers
1997	Nov	1	0	0	0
	Dec	7	0	0	0
1998	Jan	8	0	0	0
	Feb	0	2	0	0
	Mar	0	9	0	4
	Apr	0	14	0	14
	May	0	4	0	12
	Total	**16**	**29**	**0**	**30**
1998	Nov	3	0	0	0
	Dec	3	0	0	0
1999	Jan	0	0	0	0
	Feb	0	3	0	1
	Mar	0	57	0	5
	Apr	0	147	0	108
	May	0	41	1	81
	June	4	3	2	4
	Total	**10**	**251**	**3**	**199**
1999	Oct	4	0	0	0
	Nov	9	0	0	0
	Dec	24	0	1	0
2000	Jan	16	0	0	0
	Feb	0	4	0	4
	Mar	0	48	0	60
	Apr	0	47	0	60
	May	0	11	1	27
	Total	**53**	**110**	**2**	**151**
Total		**79**	**390**	**5**	**380**

Comparisons of the Warra site with New Zealand are valid as similar disturbance and climate effects enable prediction that the establishment phase will continue at Warra as long as logging and roading activity continues. Once these activities cease then over a period of several years the optimal sites will become permanently colonised and fluctuations in population will occur, tempered by weather conditions and food resources. In New Zealand 10% of studied nests over-wintered and were active for two to three seasons (Harris 1996).

Madden (1981) recorded the foraging loads of *V. germanica* at one site in Tasmania over several seasons and found that calliphorid flies were the most common prey, comprising 28.5% of total prey capture. Insects comprised

81% of foraging loads. Lewis (1975) found Diptera comprised 45.5% of protein loads, of which 23.5% were calliphorids and 18% muscids. In New Zealand, Thomas (1960) reported a marked decrease in the abundance of blowflies since *V. germanica* became established. At Warra the number of large calliphorid flies captured in the same Malaise traps was compared over time with the capture of vespine wasps. Figure 3 illustrates the average numbers of large calliphorids of four different species, captured over the years in the same traps used to sample *Vespula* populations. In 1997/98, when wasps were at low population levels during the establishment phase, numbers of calliphorids averaged over 40 individuals per month per trap during November-March then declined to 15 per month per trap in April-May. During the following summer of 1998/99, when the wasp population had increased 15 fold, calliphorids were trapped at 31 individuals per month per trap during November-February. During March-May, when wasp food gathering was at its peak, the trap catches of calliphorids declined to 2 individuals per month per trap. In 1999/2000 the calliphorid populations were low throughout the summer and declined further when high wasp numbers were present.

It is planned to continue monitoring the calliphorid and wasp populations for several seasons to investigate the possibility of long-term reduction of numbers of calliphorids and other prey species due to predation by *Vespula* species.

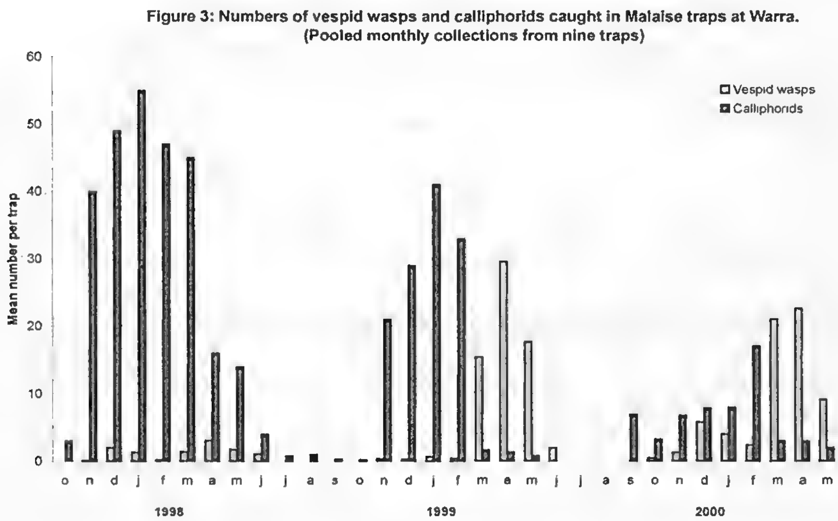

Fig. 3. Numbers of vespid wasps and calliphorids caught in Malaise traps at Warra. (Pooled monthly collections from 9 traps).

Discussion

There is little information on the impact of introduced vespine wasps on the native environment in Australia. In New Zealand the predatory effects of *Vespula* spp. on tipulid crane flies demonstrates the deleterious effect on populations of some native prey species. Up to 91% of tipulid species could be vulnerable to wasp predation (Toft and Beggs 1995). Those species of crane flies whose flight periods coincided with that of introduced *Vespula* wasps were potentially most vulnerable to direct impact from wasp predation.

Beggs and Rees (1999) examined the impact of introduced *Vespula* wasps on lepidopteran communities. The findings indicated that large free living lepidopteran larvae are particularly vulnerable, to the degree that some species whose larvae are most active at the time of peak wasp activity have virtually no chance of surviving to adults at moderate wasp densities.

Toft and Rees (1998) studied the impact of *V. vulgaris* on garden orb-web spiders in a beech forest. They found wasp abundance and the probability of spider survival were negatively correlated. The extrapolation from the model created predicts that the invertebrate taxa most vulnerable to wasp predation may have already been removed from that site ecosystem during the 40 years of wasp occupation.

Reducing populations of *Vespula* species by nest destruction has been attempted in New Zealand, with limited success because colonisation and reinvasion by foraging workers meant there was little impact on cumulative wasp biomass as measured using Malaise traps (Beggs *et al.* 1998). However, recent advances in insecticide baiting gives hope for reducing wasp populations at specific community sites such as picnic grounds, work areas such as vineyards, or unique ecosystems. Such a trial could be conducted at Warra where a 2 km wasp-free buffer currently exists between the LTER site and the South-West Conservation Area boundary. The establishment of a buffer controlled by summer trapping may prevent establishment of vespine wasps in the eastern section of the Conservation Area.

Acknowledgments

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NOTES ON THE LIFE HISTORY OF *HYPOCHRYSOPS HIPPURIS NEBULOSIS* SANDS (LEPIDOPTERA: LYCAENIDAE)

S.J. JOHNSON[1] and P.S. VALENTINE[2]

[1]*Oonoonba Veterinary Laboratory, PO Box 1085, Townsville, Qld 4810*

[2]*Tropical Environment Studies and Geography, James Cook University, Townsville, Qld 4811*

Abstract

Some larval stages and the pupa of *Hypochrysops hippuris nebulosis* Sands from northern Australia are described and illustrated. The fern *Pyrrosia lanceolata* (L.) Farw. (Polypodiaceae) is recorded as the larval food plant and the immature stages are attended by the ant *Philidris cordatus stewartii* (Forel).

Introduction

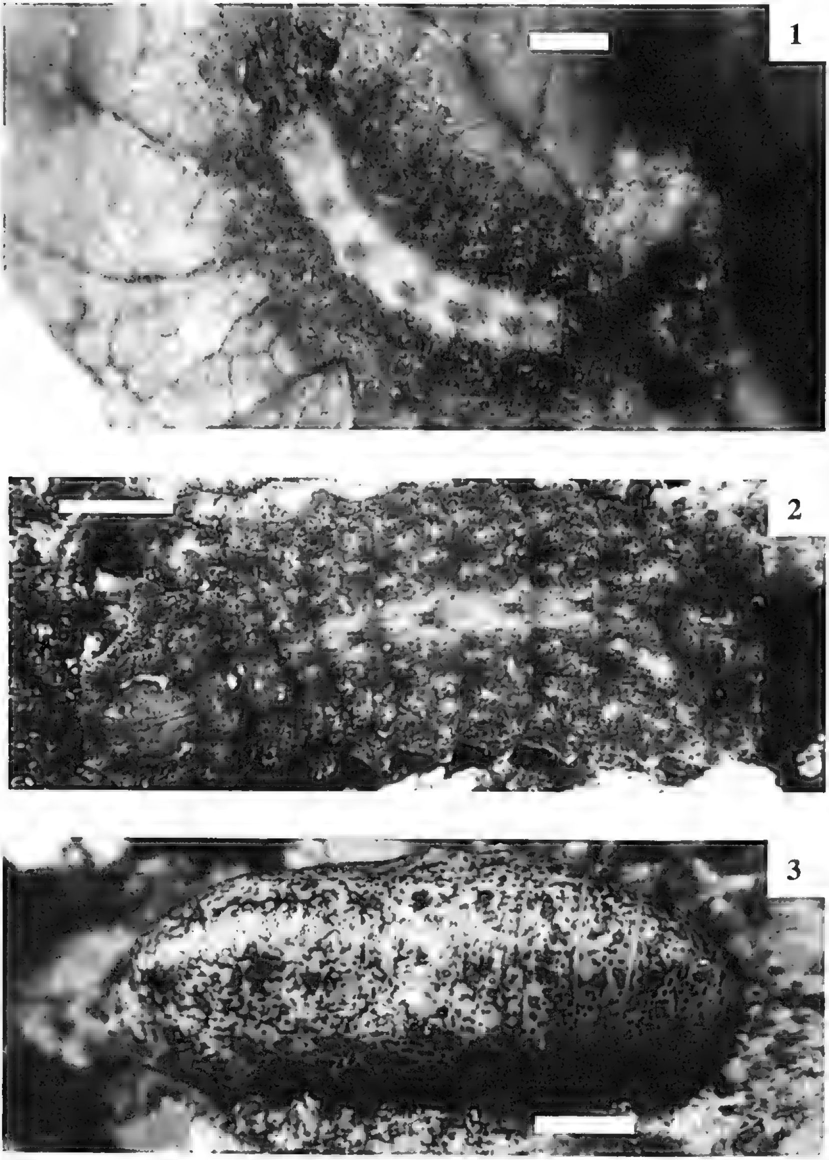
Hypochrysops hippuris nebulosis Sands is known from south-western Papua New Guinea and the Claudie River area on Cape York Peninsula, Queensland (Sands 1986). Males have been observed regularly in the morning engaged in aggressive territorial behaviour on the summits of drier hills and ridges in the rainforest but females have been seen less commonly, usually along tracks. The life history was previously unknown. Searching in an area near Gordon Creek, where we have most commonly seen females, revealed feeding scars on a small blade-like fern. Further searching on the fern using lights at night revealed larvae which were reared to adults.

Life history

Foodplant. Pyrrosia lanceolata (L.) Farw. (Polypodiaceae).

Third and fourth instar larvae (Fig. 1). Head brown; prothorax red brown with anterior margin scalloped, each protrusion bearing 3 long pale setae; prothoracic plate brown with scattered dark blotches; body reddish brown with variegated pale areas; pale green dorsal stripe extending ventrally on segment 1; abdominal segments each bearing a central dorsal rosette of red tubercles; abdominal segment 8 with a pair of raised circular black dots composed of concentric rings of erect short dark brown setae; spiracles black; abdominal segments 9 and 10 expanded laterally and posteriorly into rounded lobes, a central red triangular area and green lateral areas; body densely covered in short setae with stellate tips.

Final instar larva (Fig. 2). Flattened with scalloped margins; brown, variegated with pink, cream and green; a broad pale green dorsal stripe with central ridge tipped black; prothoracic plate pink; lateral green line along spiracles on abdominal segments 3-6; prominent black spots with pale centres laterally on abdominal segment 8; anal plate pinkish with lateral cream stripes bearing 3 small black spots; body densely covered in short stellate setae which are black overlying dark brown areas and pale brown overlying green, cream and pink areas; long pale setae ventrally and along lateral margins.



Figs 1-3. *Hypochrysops hippuris nebulosis*: (1) fourth instar larva; (2) final instar larva; (3) pupa. Scale bars = 2 mm.

Pupa (Fig. 3). Pale brown, densely mottled black; cream dorsal stripe on abdominal segments 2-6; pair of black blotches dorsolaterally on anterior mesothorax and on prothorax. Attached by anal hooks and central girdle. Length 13 mm. Pupal duration 19-21 days in Townsville in September.

Fig. 4. *Hypochrysops hippuris nebulosis* feeding scars on *Pyrrosia lanceolata*.

Observations and discussion

Despite numerous searches over the past few years we have been unable to locate eggs or early instar larvae. We have observed female *H. h. nebulosis* walking on *P. lanceolata* but have not observed oviposition. An egg dissected from a freshly dead female was pale green, suggesting oviposition may be on the fern blades; however, much of the fern grows on smaller branches and high on trunks of trees and is inaccessible.

Larvae have only been found on fern growing on trees infested with the ant *Philidris cordatus stewartii* (Forel); however, the relationship between larvae and ants appears to be facultative because several larvae found feeding or wandering on the host tree were not attended by ants. Along the Claudie River and its tributaries at Iron Range, larvae of *H. h. nebulosis* often feed on *P. lanceolata* growing on large *Nauclea orientalis* (Rubiaceae) trees containing larvae of *H. elgneri barnardi* Waterhouse.

P. lanceolata 'is an uncommon species in Australia found only on trees in the monsoonal rainforests of the ranges of central Cape York Peninsula' (Jones and Clemesha 1976). Feeding scars (Fig. 4) made by larvae of *H. hippuris* are widespread along the Claudie River valley and we have observed them commonly on fern up to 15 metres high but less so on fern growing above this height. We have not found feeding scars on fern growing on trees not infested with *P. c. stewartii*. Greg Daniels collected a female

around a bird's nest fern but oviposition was not observed (Common and Waterhouse 1981). Bird's nest ferns commonly grow with *P. lanceolata* at Iron Range and, in our experience, frequently contain large nests of *P. cordatus*, but we have not found larvae or signs of larval feeding on these ferns. The trees supporting plants of *P. lanceolata* are also covered in mosses and the stems of the fern trap fallen leaves and detritus. Larvae reared on fern growing on recently fallen branches constructed shelters by tunnelling into the moss and detritus and the variegated green and pink colouration of the larvae afforded excellent crypsis. Pupation occurred in the larval shelter. Three larvae collected in July 1996 were parasitised by an unidentified braconid wasp.

H. hippuris Hewitson is only the second butterfly species known to use ferns as a food plant, although Sands (1986) observed a female of *H. dohertyi* Oberthür apparently engaged in oviposition behaviour around a fern in Papua New Guinea. The closely related *H. theon* C. & R. Felder uses the ferns *Drynaria quercifolia* (Daniels 1976) and *Platycerium hillii* (Lane 1993) in Australia and larvae are attended by the same ant as larvae of *H. h. nebulosis*. At Iron Range, *D. quercifolia* occurs commonly on the base of trees also hosting *P. lanceolata* and infested with *P. cordatus* but we have not observed larvae of the two butterfly species together.

The record by D.P.A. Sands (in Braby 2000) of *Polypodium* sp. as a food plant of *H. h. nebulosis* cannot be verified. No adults were reared to confirm the reputed larval identification and *Polypodium* is not known to occur in Queensland (Henderson 1997). *H. h. nebulosis* is known only from the Claudie River valley in Australia, suggesting that *P. lanceolata* may be its only food plant in Australia.

Acknowledgments

We thank Mick and Clare Blackman for assistance during field work, the Queensland Herbarium for food plant identification and the Department of Environment for permits to undertake work in areas under their control.

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A NEW SPECIES OF *DELIAS* HÜBNER (LEPIDOPTERA: PIERIDAE) FROM NEW IRELAND, PAPUA NEW GUINEA

CHRIS J. MÜLLER

Indochina Goldfields, Jl. 141, Sumatera, Tarakan, Kalimantan Timur, Indonesia
(address for correspondence: PO Box 3228, Dural, NSW 2158)

Abstract

Delias brandti sp. nov. is described and figured from the mountains of New Ireland. It is placed in a species group of its own, based on distinctive genitalia. Notes on the distribution of *D. messalina lizzae* Müller in New Ireland are also included.

Introduction

The large genus *Delias* Hübner contains butterflies that commonly have brightly coloured undersides. They are distributed throughout the Asia-Pacific region from India, China and Taiwan to Australia, Solomon Islands, Vanuatu and New Caledonia. Based on similar genitalia, Klots (1933) considered that the closest relative of *Delias* is *Cepora* Billberg. He also noted that the pupae of the Neotropical *Pereute* Herrich-Schäeffer are indistinguishable from those of *Delias*. Corbet and Pendlebury (1978) suggested that *Delias*, *Pereute* and the African genus *Mylothris* Hübner probably form a good tribe.

The revision of *Delias* by Talbot (1928-37) remains the major work to date, although much literature dealing with the genus has been published since, including that of Roepke (1955), van Mastrigt (1989, 1990, 1993) and Yagashita *et al.* (1993). The latter work listed around 230 species, although a proportion of these are of dubious status.

In February 1998, during a visit to the Australian National Insect Collection, Canberra, an unusual female *Delias* specimen from New Ireland in the W. W. Brandt collection was noticed, prompting a trip to montane New Ireland in July-August 1998. This specimen was later figured by Parsons (1998) as the female of *D. narses* Heller. The specimen does not correspond with females of *D. narses* from New Ireland in the author's collection and another from New Britain in the Australian Museum, Sydney. This error may be attributed to the extreme rarity of *D. narses* females in collections, combined with the identification label with the ANIC female that states *D. narses*.

In late August 1998, three specimens of an undescribed *Delias* were observed but not captured as they flew at great height over a spine ridge at about 1800 m in the Hans Meyer Range, southern New Ireland. As a result, during October-November 2000, a further expedition was undertaken into the southern mountains of New Ireland by the author. Two males and a single female of this species were collected, also at 1800 m. This new species is described here and shows very distinctive characters, especially its unusual genitalic morphology.

This work is one of a series of papers dealing with the taxonomy and biology of the butterflies of New Ireland (Müller 1999a, b, 2001; Müller and Sands 1999; Müller and Tennent 1999).

Abbreviations in this work are as follows: ANIC - Australian National Insect Collection, CSIRO, Canberra; AM - Australian Museum, Sydney; CJMC - Private collection of C. J. Müller, Sydney.

Delias brandti sp. nov.

(Figs 1-4, 18)

Type material. Holotype ♂ (genitalia dissected and attached to specimen), PAPUA NEW GUINEA: Schleinitz Mts., 1800 m, south-central New Ireland, 20.x.2000, C.J. Müller (in ANIC). *Paratypes*: 1 ♂, 1 ♀, same data as holotype (CJMC); 1 ♀, Schleinitz Mts., 3000 ft, 2.x.-18.xii.1959, W.W. Brandt, Sir E. Hallstrom (ANIC).

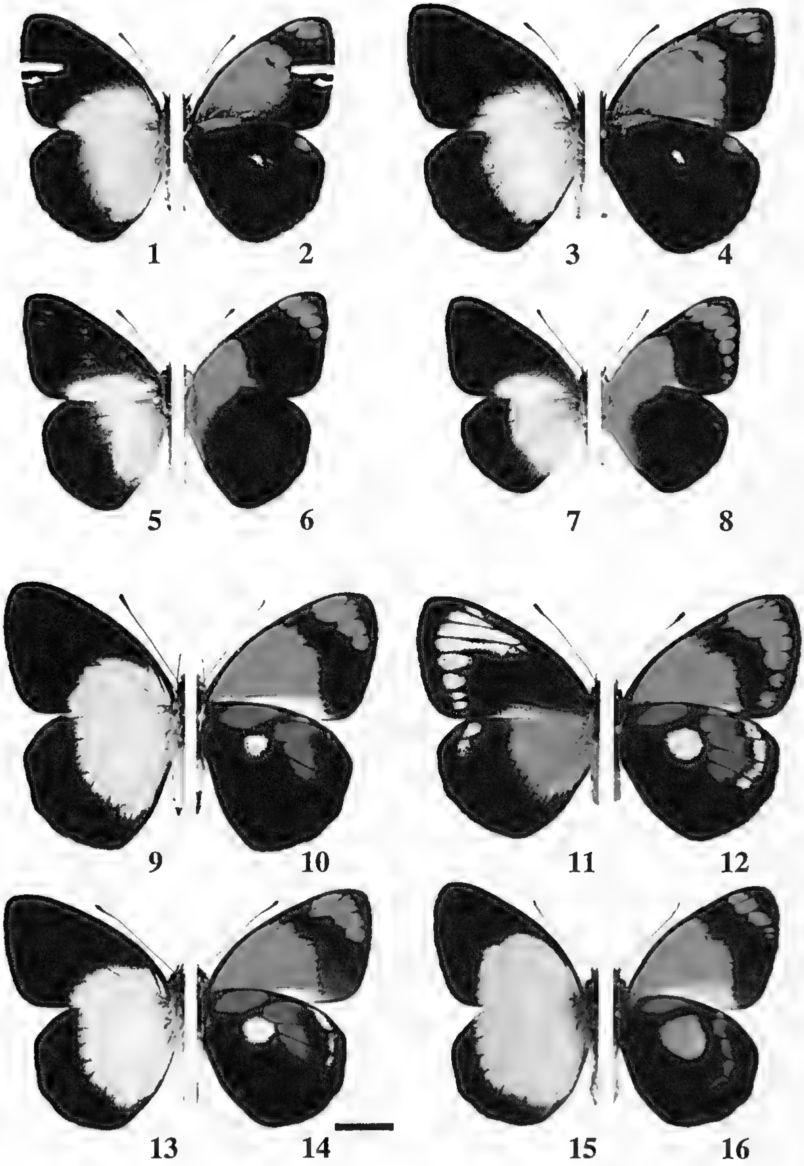
Description. Male (Figs 1, 2). Fore wing length 28 mm, antenna 14 mm. Head black, clothed with dense, deep grey hairs; labial palpus grey-cream, eye ringed with grey-cream; antenna black. Thorax black with long grey hairs dorsally; legs black. Abdomen white, valvae grey. Fore wing with costa slightly bowed towards base; upperside with ground colour black, basal one-third creamy white, cilia black; underside black with basal two-thirds chrome yellow, becoming irregular below vein 1A+2A; conspicuous black spot at end of cell between veins M_2 and M_3; subapical region with chrome yellow band, broken by veins. Hind wing upperside black with basal half creamy white, darkening to blue-grey in median area; underside with ground colour black; chrome yellow bar along costa at base; a small subapical spot of similar colour between veins Rs and M_1; a small white spot in discocellular region between veins M_2 and M_3.

Genitalia (Fig. 18). Vinculum and tegumen ring broadly oval; uncus stout, ornate and rugose, blackened anteriorly; valva short and squat, covered with short, thick hair, apex blunt, ventral margin bowed centrally; saccus squat and rounded; aedeagus squared both anteriorly and posteriorly.

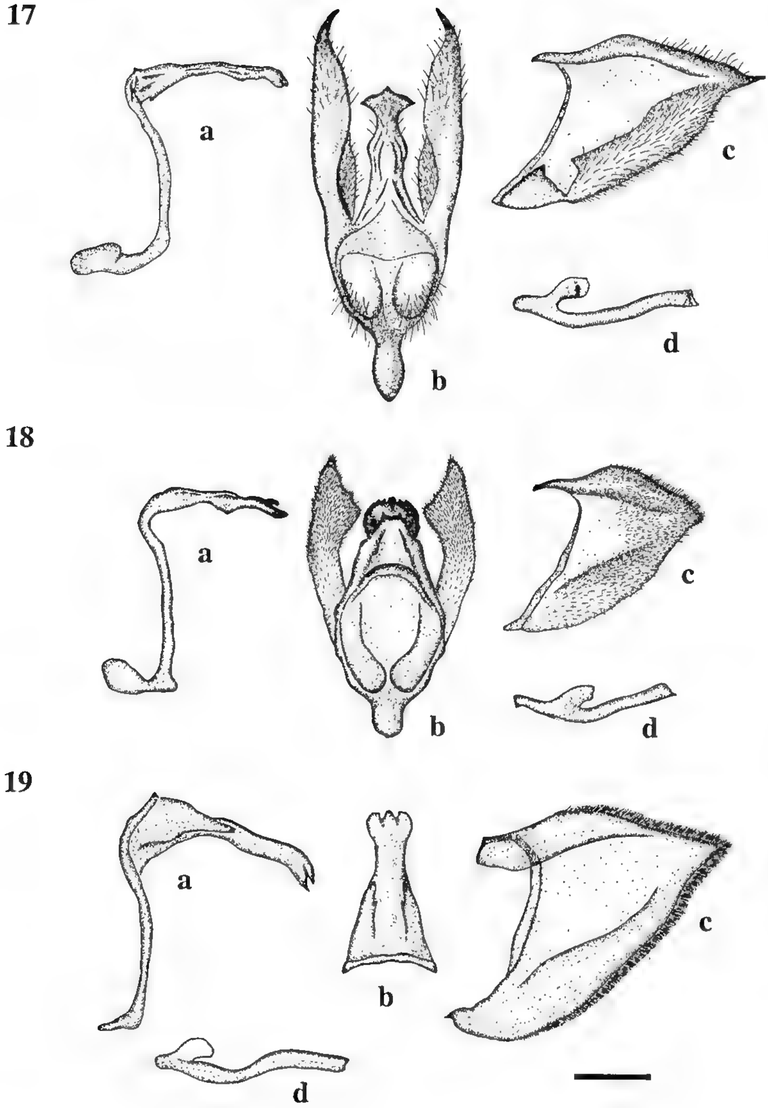
Female (Figs 3, 4). Fore wing length 29 mm, antenna 15 mm. As in male but with both wings broader; pale basal area on upperside with a yellow-cream suffusion; underside with chrome yellow on fore wing more extensive and reaching inner margin.

Etymology. This distinctive new species is named in honour of W. W. Brandt, who collected one of the female paratypes in the Schleinitz Mountains in 1959. Brandt spent a decade collecting in very remote parts of Papua New Guinea, his efforts resulting in the subsequent description of many taxa.

Early stages. Unknown.



Figs 1-16. *Delias* adults from New Ireland and Bougainville. Odd numbers upperside, even numbers underside. (1, 2) *D. brandti* sp. nov. ♂; (3, 4) *D. brandti* ♀; (5, 6) *D. narses* ♂; (7, 8) *D. narses* ♀; (9, 10) *D. messalina lizzae* ♂; (11, 12) *D. m. lizzae* ♀; (13, 14) *D. m. lizzae* ♂; (15, 16) *D. m. messalina* ♂. Scale bar = 1 cm.



Figs 17-19. Male genitalia of *Delias* from New Ireland. (17) *D. narses*; a. genitalic ring (lateral view); b. genitalia (dorsal view); c. right valva (lateral view); d. aedeagus (lateral view). (18) *D. brandti* sp. nov.; a. genitalic ring (lateral view); b. genitalia (dorsal view); c. right valva (lateral view); d. aedeagus (lateral view). (19) *D. messalina lizzae*; a. genitalic ring (lateral view); b. sociuncus (dorsal view); c. right valva (lateral view); d. aedeagus (lateral view). Scale bar = 1 mm.

Discussion

The division of *Delias* into species groups by Talbot (1928-37) was based mainly on a detailed study of genitalia and androconial form. *Delias brandti* is unlike any other known *Delias* species. It shows vague wing pattern similiarities with *D. ladas* Grose-Smith, *D. caliban* Grose-Smith (both *chrysomelaena* species group) and *D. messalina* Arora (*nigrina* species group). In particular, the latter species shares a similar white or yellow spot in the median area of the hind wing underside, while the wing shape is reminiscent of *D. eximia* Rothschild (also *nigrina* species group). In *D. messalina* this spot is centred in the cell (Figs 9-16), while in *D. brandti* it is situated along the discocellulars between the veins M_2 and M_3. The fore wing underside pattern is distinctive in *D. brandti*, the blackened discocellulars being very unusual in *Delias*. The new taxon shows no close relationship to *D. narses* (Figs 5-8, 17).

The genitalia of *D. brandti* are unique (Fig. 18), particularly the uncus which is squat and rugose. While the adults are dissimilar in appearance, the genitalia of *D. vidua* Joicey & Talbot (*nysa* species group) and *D. brandti* show some minor similarities. The distinctive genitalia of *D. brandti* suggest that it should be placed in a species group of its own, related to the *nigrina*, *nysa* and *chrysomelaena* species groups.

Adults of *D. brandti* were collected flying over the canopy on a ridge summit, at around 1800 m, where the vegetation is montane moss forest and the tree canopy approximately 15-20 m high. They were taken flying with *D. messalina lizzae* Müller and other *Delias* taxa. The flight of this species is more rapid than *D. messalina lizzae*, while not as robust as that of *D. narses* and *D. totila* Heller.

Delias messalina lizzae was previously known only from 6 specimens taken at 2400 m in the Hans Meyer Range in 1998. A small number of males was collected during October-November 2000 in the same mountain range at 1800 m, approximately 80 km NNW from the type locality. In addition, two males were taken in the Schleinitz Mountains, central New Ireland at 1400 m. *D. m. lizzae* is highly variable, both in wing shape and extent of the bright markings beneath. Most of the known males are similar to the holotype, with a rather acute wing shape and lacking pale grey submarginal markings on the hind wing underside (Figs 9, 10). Two specimens, however, have more rounded wings and a grey submarginal line on the hind wing underside (Figs 13, 14). Females vary in the extent of the white submarginal markings on the upperside of both wings. The male genitalia are also illustrated (Fig. 19).

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THE PREVIOUSLY UNKNOWN FEMALES OF *LEUCIACRIA OLIVEI* MÜLLER AND *PSEUDODIPSAS UNA* D'ABRERA (LEPIDOPTERA: PIERIDAE AND LYCAENIDAE)

CHRIS J. MÜLLER

Indochina Goldfields, Jl. 141 Sumatera, Tarakan, Kalimantan Timur, Indonesia

(address for correspondence: PO Box 3228, Dural, NSW 2158)

Abstract

Females of the Papuan *Leuciacria olivei* Müller and *Pseudodipsas una* D'Abrera are described and figured. The known distribution of *L. olivei* in New Ireland is extended.

Introduction

Leuciacria olivei Müller was described from five males taken in southern New Ireland at 2400 m (Müller 1999). Recently, a series of males and a single female were collected in south-central New Ireland, at approximately 1800 m.

Pseudodipsas una D'Abrera was known previously only by a single male from an unknown locality in New Ireland (Parsons 1998). It was described originally as a subspecies of *P. eone* (C. & R. Felder) (D'Abrera 1971).

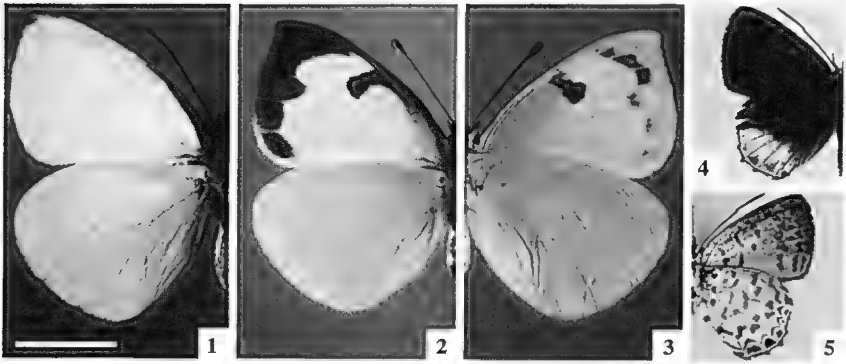
Descriptions

Leuciacria olivei Müller

Female (Figs 2, 3). Fore wing length 25 mm, antenna 13 mm. Head black with dense, deep grey hair tufts, whitish-grey ventrally; antenna black, with conspicuous flat club; labial palpus deep grey. Thorax black above, pinkish-cream beneath. Abdomen white, black dorsally, claspers grey. Fore wing concave between apex and vein M_2, convex between tornus and vein M_2, apex pointed; above cream-yellow, costa and termen broadly black, large black spot in postmedian area of cell; beneath cream with irregular black subterminal markings and large black spot at end of cell, remainder of cell yellow. Hind wing rather elongate, above pale yellow; beneath cream with yellow-green suffusion, costa bright yellow.

Pseudodipsa una D'Abrera

Female (Figs 4, 5). Fore wing length 13 mm, antenna 9 mm. Head, thorax and abdomen black dorsally, white ventrally; antenna black with obscure white ribs; labial palpus grey. Fore wing costa straight, termen slightly convex; above dark brown, cilia dark brown; beneath light grey, dark brown in subterminal region, a pair of irregular but continuous triangle-shaped dark brown postmedian and subterminal bands, three broken dark brown bands in basal and median area. Hind wing with termen slightly pronounced between tornus and vein M_2, above dark brown, large pale silver-blue subtornal area, with dark brown indistinct subterminal spots between vein M_3 and tornus, cilia dark brown; beneath pale grey with a series of regularly spaced brown bands, subtornal spots large and dark brown.



Figs 1-5. (1) *Leuciacria olivei* male, upperside. (2) *L. olivei* female, upperside. (3) *L. olivei* female, underside. (4) *Pseudodipsas una* female, upperside. (5) *P. una* female, underside. Scale bar = 1 cm.

Discussion

Leuciacria olivei is sexually dimorphic. The described female differs markedly from those of *L. acuta* Rothschild & Jordan in the more elongate hind wing, absence of markings on the hind wing, large fore wing cell spot and overall yellow suffusion of both wing surfaces. The holotype male of *L. olivei* has more black on the fore wing apex than other known specimens; the majority possess little or no black on the fore wing (Fig. 1). In addition to the types and other specimens taken in the Hans Meyer Range, southern New Ireland, several males were observed flying about 20 m above the ground in the Schleinitz Mountains, central New Ireland, at 1400 m, extending the known range approximately 200 km north-east.

Females of *P. una* closely resemble males but have broader, more rounded wings. Both sexes may be distinguished from other *Pseudodipsas* C. & R. Felder species by the absence of orange markings around the tornal spots on the hind wing underside. Females also have an extensive pale blue subtornal area on the hind wing upperside. The described female was collected in a forested gully in the Schleinitz Mountains at 1000 m, where it was flying with several other lycaenids, including *Erysichton albiplaga* Tite. At least two males of *P. una* were observed to fly rapidly and settle briefly on a ridge summit at 1100 m.

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BOOK REVIEW

Butterflies of Australia. Their Identification, Biology and Distribution. By M.F. Braby. CSIRO Publishing; August 2000; 2 vols; xx + vii + 976 pp; 70 colour plates; hardback. Price $195. ISBN 0 643 06591 1.

This long-awaited work is undoubtedly the most significant contribution to the literature on Australian butterflies since the 1981 second edition of Common and Waterhouse's *Butterflies of Australia*, with the number of species recognised from Australia (including Torres Strait islands) increasing from 382 in the former work to 410 in the present volumes (plus a further 4 from outlying islands).

The inclusion, in appendices, of the fauna of Christmas, Cocos (Keeling) and Norfolk Islands is welcome, but the downgrading of the fauna of Lord Howe Island and the northern and eastern Torres Strait islands to the same appendices is regrettable; these have long been accepted as an integral part of Australia. It is unusual to find a book on a country's fauna that defines its scope by zoogeographical, rather than political boundaries and a more appropriate title might be *Butterflies of the Australian Faunal Subregion*.

Introductory chapters provide an overview of biology, classification, collection and study. With the exception of the section on Conservation, these differ little from those in Common and Waterhouse and the contributions of that work to the present one remain significant.

The species listings provide the bulk of the text and include updated information on both nomenclature and biology, particularly life histories. In many cases, there are also useful notes on variation, taxonomic status, distribution and habits. Although impressive, these listings are not without problems. The requirement of the International Code of Zoological Nomenclature regarding agreement in gender between species and genus names has been disregarded. This means that the work cannot be used as a reliable guide to the correct spelling of names; for this Common and Waterhouse remains the authority. It is to be hoped that subsequent editions will rectify this breach of the Code. In the Papilionidae, the tribal name Lampropterini should be used in preference to Graphiini.

There is a greatly reduced emphasis on subspecies. Many have been synonymised, some justifiably but others perhaps a little too hastily and without proper consideration. Two species have been reduced in status on very doubtful grounds. *Jalmenus notocrucifer* has been tentatively placed as a subspecies of *J. inous* in a move which serves no useful purpose. *Elodina tongura* has been placed as a seasonal form of *E. walkeri*, despite differences in the aedeagus and its restriction to coastal and insular Northern Territory; a seasonal form would be expected to occur throughout the range of the species, including Queensland. Many pierid genera contain cryptic species

that are very difficult to tell apart. A better understanding may result from DNA, pheromone or ecological data but until then, and in the interests of stability, the prevailing treatments should have been maintained. The treatment of the *Ornithoptera* species, with the evidently sister-taxa *richmondia* and *euphorion* (a relationship supported by morphological and hybridisation data) placed as a species (*O. richmondia*) or a subspecies (*O. priamus euphorion*), defies both logic and phylogenetic reasoning.

Positive aspects of the book include the 64 excellent colour plates of set adult specimens. All but 2 species (*Pseudoborbo bevani* and *Appias celestina*, both likely vagrants) are illustrated thus. The 6 colour plates of early stages and adults in life are also welcome, although given the wealth of life history information available, perhaps more of these could have been included. Alternatively, there is scope for a companion volume on life histories.

There are very few typographical errors. The black and white illustrations provided for each species are a very useful addition to the text, particularly with the highlighting of diagnostic features. This is especially so in the case of the Hesperiidae and Lycaenidae, where many species are difficult to identify. The maps are more precise than in Common and Waterhouse, distributions more closely approximating actual records rather than broad extrapolations. In some cases this gives the impression that widespread species are absent from large tracts of country and some available records have been omitted (e.g. from western Cape York Peninsula).

There are useful appendices of larval food plants and attendant ants, species protected by legislation and a glossary. The appendix on species considered to be of conservation concern is less useful; it is too subjective and superficial for a book of this kind.

Many of the above criticisms appear to result from following the precedents set by the 1996 *Checklist of the Lepidoptera of Australia* by Nielsen, Edwards and Rangsi. These aside, this is a very worthwhile addition to the literature and the author should be congratulated for his perseverance and attention to detail. It is attractively presented and a delight to use. In its large, hardback form it is too cumbersome to be used as a field guide and a much abridged version may find a ready market. However, I have no doubt that this work deserves a place on the bookshelf of everyone interested in the Australian butterfly fauna. For those actively involved with the subject it is something of a necessity.

David L. Hancock

NOTES ON THE LIFE HISTORY OF *CHILASA MOERNERI MOERNERI* (AURIVILLIUS) (LEPIDOPTERA: PAPILIONIDAE)

C. J. MÜLLER

Indochina Goldfields, Jl. 141, Sumatera, Tarakan, Kalimantan Timur, Indonesia

(address for correspondence: PO Box 3228, Dural, NSW 2158)

Abstract

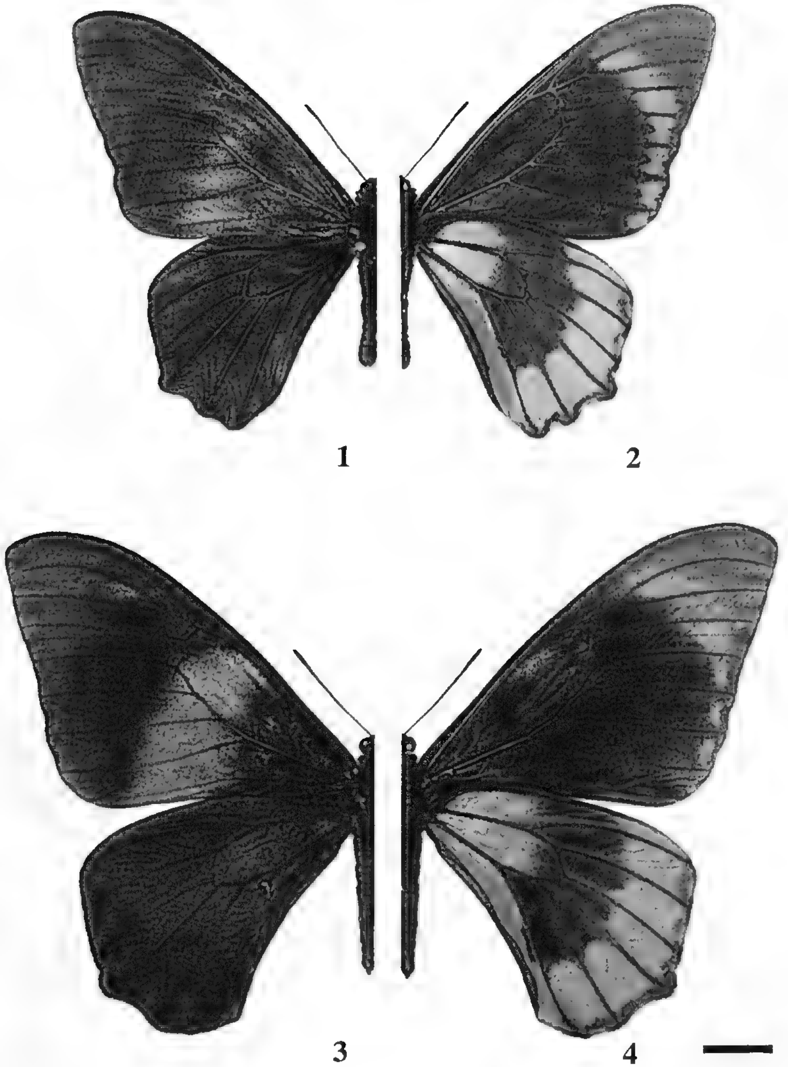
The pre-pupal larva and pupa of *Chilasa moerneri moerneri* (Aurivillius), from New Ireland, Papua New Guinea, are described and figured. Adults of both sexes are also illustrated, previous photographs of the male being a misidentified female.

Introduction

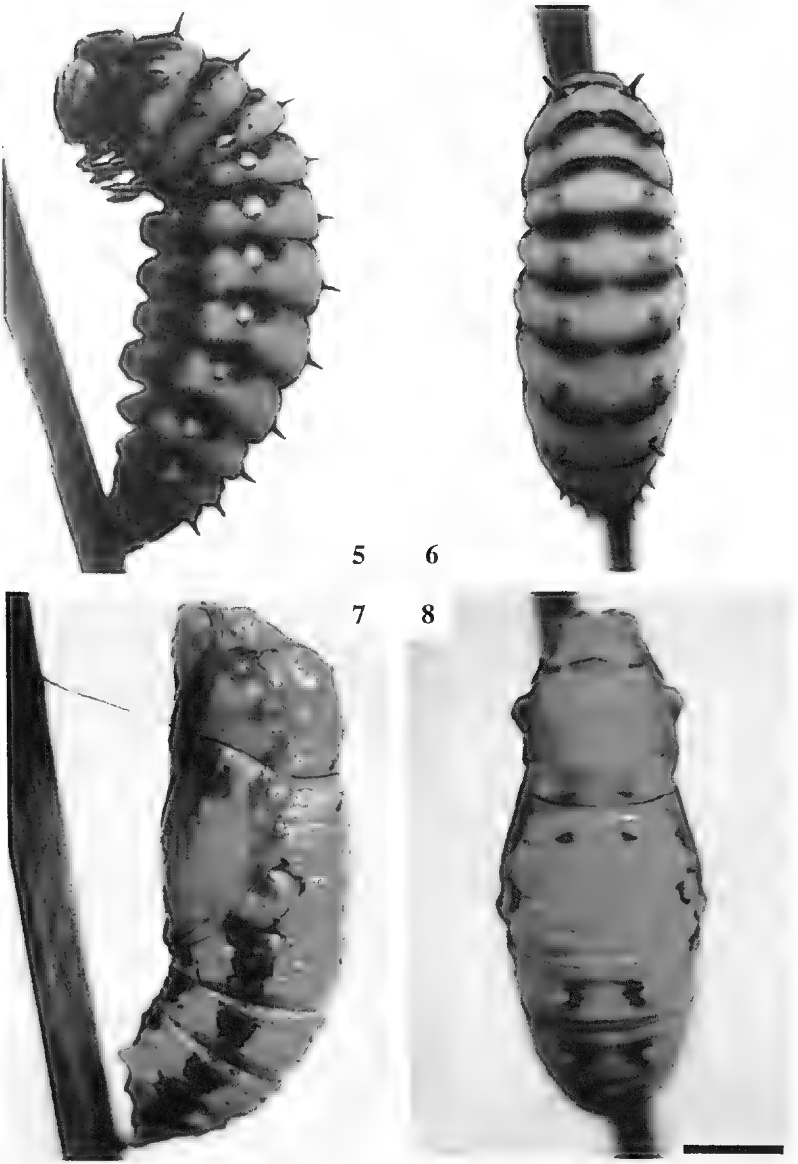
Chilasa moerneri (Aurivillius) has commonly been placed within *Papilio* Linnaeus. Hancock (1983), however, referred it, together with *C. laglaizei* (Depuiset) and *C. toboroi* (Ribbe), to *Chilasa* Moore, which may be separated into subgenera *Chilasa* and *Agehana* Matsumura. *Chilasa laglaizei* is known from Aru, Waigeo and mainland New Guinea (Parsons 1998), while *C. toboroi* is recorded from Bougainville and the Solomon Islands. Subspecies *C. t. straatmani* Racheli was described from a single male from Santa Isabel (Racheli 1979), while Straatman (1975) and Parsons (1998) additionally recorded this taxon from Malaita Island, where John Tennent (pers. comm., 1997) has also seen specimens flying.

Aurivillius (1919) described *C. moerneri*, after a Mr. Birger Mörner, from a single male from New Ireland that was illustrated as a black and white line drawing. This holotype male is missing and there is no record of any published photographs of it. Typical *C. m. moerneri* was otherwise only known from two females and D'Abrera (1971) suggested (erroneously) that the butterfly was probably extinct. The two females are in the Natural History Museum, London and the Australian National Insect Collection, respectively. The former specimen was figured as a male by both Parsons (1998) and D'Abrera (1971, 1978, 1990). Additionally, Straatman (1975) stated that he saw a few specimens taken in New Ireland during 1968. Subspecies *C. m. mayhoferi* Bang-Haas was described also from a single male taken in the south-eastern Bainings Mountains, eastern New Britain, at 700 m (Bang-Haas 1939). This specimen has never been illustrated and is now also apparently lost.

During July, 1998 two pre-pupal larvae and a dead pupa of *C. m. moerneri* were discovered by the author in a small clearing in montane rainforest at approximately 1000 m in the Schleinitz Mountains, central New Ireland. These emerged as a pair (Figs 1-4), a photograph of the true male being provided for the first time.



Figs 1-4. Adults of *Chilasa moerneri moerneri*. Odd numbers uppersides, even numbers undersides. (1, 2) male; (3, 4) female. Scale bar = 1 cm.



Figs 5-8. Early stages of *Chilasa moerneri moerneri*. (5) pre-pupal larva (lateral view); (6) pre-pupal larva (dorsal view); (7) pupa (lateral view); (8) pupa (dorsal view). Scale bar = 1 cm.

Life history

Larva. Pre-pupal stage (Figs 5, 7) 61 mm long; prothoracic shield and head black; body ground colour pale ochreous yellow; body segments with a pair of black dorsolateral tubercles about 4.5 mm long with broad black bases; all segments joined by broad, black ring, widening laterally into large, triangular spot below spiracles, middorsally each ring with a white, elongated spot.

Pupa (Figs 6, 8). 58 mm long; leathery; head with shallow central trough; abdominal segment 8 with a long and segment 9 with a shorter, blunt appendage lateroventrally; cremaster broad and cephalad, yellow dorsally, black ventrally; abdominal segments each with a pair of small dorsolateral humps; thoracic segments with two pairs of humps, those laterally are more prominent than dorsolateral humps; ground colour cadmium yellow; segments 5-9 and inner margin of wing case laterally with broken, broad, brown stripe surrounding the spiracles.

Discussion

The pre-pupae and pupae of *C. moerneri* are morphologically similar to those of *C. laglaizei* and *C. toboroi*, as described by Straatman (1975), but are distinctive in some respects. The pre-pupal larvae of all three species have rugose dorsolateral tubercles and are yellow with black segments and black and white lateral spots. The pre-pupa of *C. moerneri* has tubercles that are intermediate in length between those of *C. laglaizei* and *C. toboroi*.

Pupae of *C. moerneri* are similar to the other two species, all three having a characteristic cylindrical, leathery appearance and a yellow ground colour broken by a series of dark, lateral, abdominal spots. The pupa of *C. moerneri* is slightly darker than that of *C. laglaizei* and *C. toboroi* and the dorsolateral humps on the thorax are much less prominent. For both of the specimens discussed here, pupation occurred at around 3 am and adults emerged 16 days later at approximately 8 am. Straatman (1975) recorded pupal durations of 14-16 and 16-18 days respectively for *C. laglaizei* and *C. toboroi*.

Shortly after eclosion, both adults promptly dropped to the ground, apparently being very weak. Each adult had to be held between thumb and forefinger for around three hours as they could only be persuaded to hold onto netting material for a short time. The apparent rarity of *C. moerneri* in nature may possibly be attributed to the poor ability of adults to expand and dry their wings upon emergence.

The larval foodplant of *C. moerneri* is unknown. Both *C. laglaizei* and *C. toboroi* are known to feed on plants belonging to the Lauraceae (Straatman 1975). Several lauraceous plants (including *Litsea* sp.) were noted within 15 metres of the pre-pupal larvae, which were located on low vegetation less than 30 cm from the ground.

Only a single specimen of *C. moerneri*, a female, was observed by the author during 2 months field research in New Ireland in 1998. In flight, the female was reminiscent of a large *Eleppone anactus* (W. S. Macleay) from Australia but was more aggressive and flew at canopy level. It was noted to pause briefly at flowers some 25 m above the ground. A further field trip to New Ireland during October-November 2000 yielded no adults or early stages of this taxon.

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CONTENTS

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